

Gas Stoichiometry Problems

For the following, if no P or T is given, then use P = 101.3 kPa and T = 298 K.

- 1) Calcium carbonate decomposes at high temperatures to form carbon dioxide and calcium oxide. How many grams of calcium carbonate will be needed to form 3.45 liters of carbon dioxide? (14.1 g)



$$m = ?$$

$$V = 3.45 \text{ L}$$

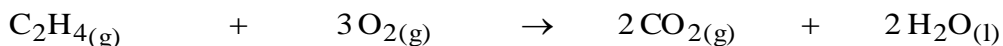
$$M = 100.09 \text{ g/mol}$$

$$P = 101.3 \text{ kPa}$$

$$T = 298 \text{ K}$$

$$\begin{aligned} m_{\text{CaCO}_3} &= \frac{PV}{RT} \times \frac{\# \text{ mol CaCO}_3}{\# \text{ mol CO}_2} \times M_{\text{CaCO}_3} \\ &= \frac{101.3 \text{ kPa} \times 3.45 \text{ L}}{8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 298 \text{ K}} \times \frac{1 \text{ mol CaCO}_3}{1 \text{ mol CO}_2} \times \frac{100.09 \text{ g}}{1 \text{ mol CaCO}_3} \\ &= 14.1 \text{ g} \end{aligned}$$

- 2) Ethylene burns in oxygen to form carbon dioxide and water vapor. How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction? (2.50 L)



$$V = 1.25 \text{ L}$$

$$V = ?$$

$$P = 101.3 \text{ kPa}$$

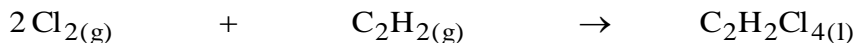
$$P = 101.3 \text{ kPa}$$

$$T = 298 \text{ K}$$

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$$\begin{aligned} V_{\text{H}_2\text{O}} &= V_{\text{C}_2\text{H}_4} \times \frac{\# \text{ mol H}_2\text{O}}{\# \text{ mol C}_2\text{H}_4} \\ &= 1.25 \text{ L} \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol C}_2\text{H}_4} \\ &= 2.50 \text{ L} \end{aligned}$$

- 3) When chlorine is added to acetylene, 1,1,2,2-tetrachloroethane is formed. How many liters of chlorine will be needed to make 75.0 grams of C₂H₂Cl₄? (21.9 L)



$$V = ?$$

$$m = 75.0 \text{ g}$$

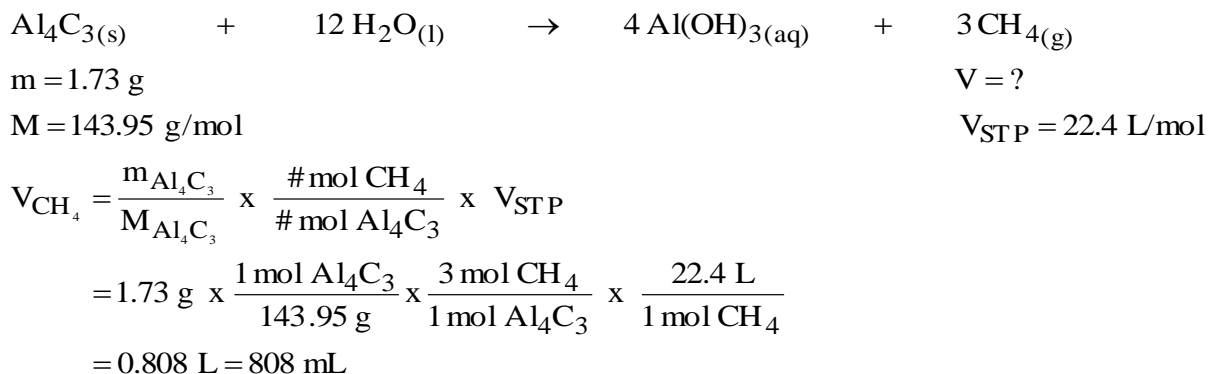
$$P = 101.3 \text{ kPa}$$

$$M = 167.84 \text{ g/mol}$$

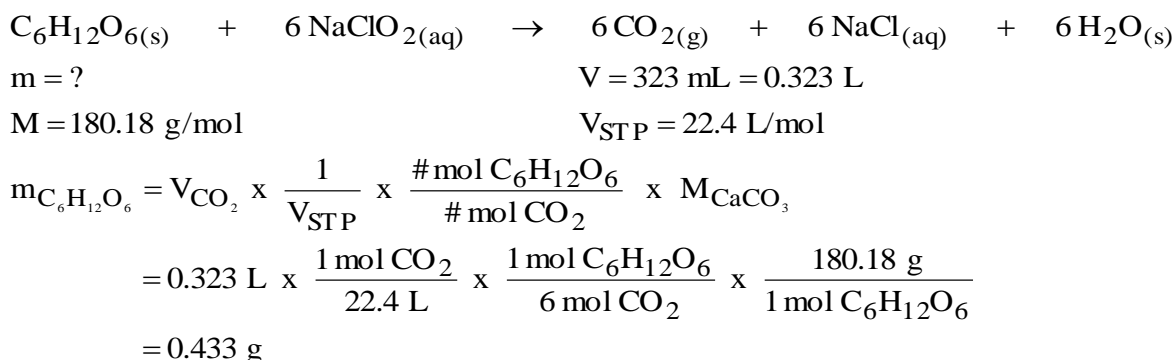
$$T = 298 \text{ K}$$

$$\begin{aligned} V_{\text{Cl}_2} &= \frac{m_{\text{C}_2\text{H}_2\text{Cl}_4}}{M_{\text{C}_2\text{H}_2\text{Cl}_4}} \times \frac{\# \text{ mol Cl}_2}{\# \text{ mol C}_2\text{H}_2\text{Cl}_4} \times \frac{RT}{P} \\ &= 75.0 \text{ g} \times \frac{1 \text{ mol C}_2\text{H}_2\text{Cl}_4}{167.84 \text{ g}} \times \frac{2 \text{ mol Cl}_2}{1 \text{ mol C}_2\text{H}_2\text{Cl}_4} \times \frac{8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 298 \text{ K}}{101.3 \text{ kPa}} \\ &= 21.9 \text{ L} \end{aligned}$$

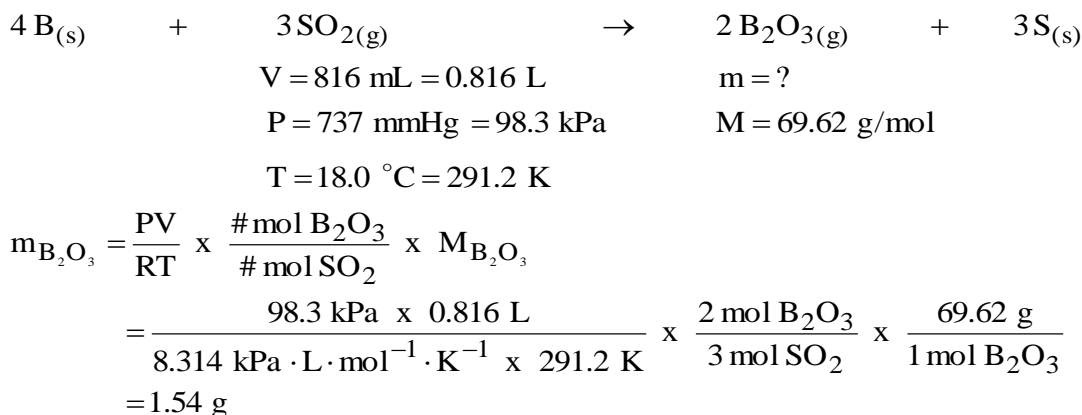
- 4) Methane, CH₄, gas can be made in small quantities by the reaction shown below. How many ml of CH₄(g), at STP will be produced when 1.73 grams of aluminum carbide, Al₄C₃, completely react with water? (808 mL)



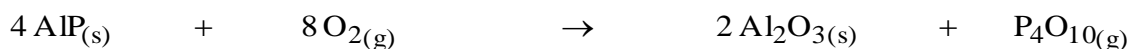
- 5) Carbon dioxide gas can be produced by the action of sodium chlorite upon glucose according to the equation given below. If 323 ml of carbon dioxide, CO₂, at STP, came from the reaction, how many grams of glucose, C₆H₁₂O₆, reacted? (0.433 g)



- 6) The element boron, B, reacts with sulfur dioxide gas, SO₂, to produce boron(III) oxide, B₂O₃, and sulfur, S, according to the following equation. How many grams of boron(III) oxide will be produced if 816 mL of SO₂ at 737 mm Hg pressure and 18°C react (1.54 g)



- 7) Aluminum phosphide, AlP, reacts with oxygen gas, O₂, making aluminum oxide, Al₂O₃, and phosphorous(V) oxide, P₄O₁₀. What volume of oxygen gas at 879.0 torr and 31.0 °C will be needed to produce 3.76 g of aluminum oxide? (3180 mL)



$$V = ?$$

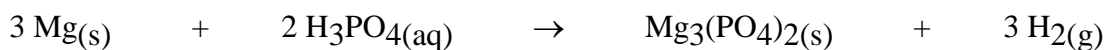
$$m = 3.76 \text{ g}$$

$$P = 879.0 \text{ torr} = 117.2 \text{ kPa} \quad M = 101.96 \text{ g/mol}$$

$$T = 31.0 \text{ }^\circ\text{C} = 304.2 \text{ K}$$

$$\begin{aligned} V_{\text{O}_2} &= \frac{m_{\text{Al}_2\text{O}_3}}{M_{\text{Al}_2\text{O}_3}} \times \frac{\# \text{ mol O}_2}{\# \text{ mol Al}_2\text{O}_3} \times \frac{RT}{P} \\ &= 3.76 \text{ g} \times \frac{1 \text{ mol Al}_2\text{O}_3}{101.96 \text{ g}} \times \frac{8 \text{ mol O}_2}{2 \text{ mol Al}_2\text{O}_3} \times \frac{8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 304.2 \text{ K}}{117.2 \text{ kPa}} \\ &= 3.18 \text{ L} = 3,180 \text{ mL} \end{aligned}$$

- 8) Magnesium reacts vigorously with phosphorous acid to produce magnesium phosphate and hydrogen. When 5.25 g of Mg reacts with 100. mL of 1.50 M H₃PO₄ at 91.7 kPa and 15.0 °C react, how many litres of hydrogen gas will be produced? (5.64 L)



$$m = 0.525 \text{ g}$$

$$V = 100. \text{ mL} = 0.100 \text{ L}$$

$$V = ?$$

$$M = 24.31 \text{ g/mol}$$

$$C = 0.150 \text{ mol/L}$$

$$P = 91.7 \text{ kPa}$$

$$T = 15.0 \text{ }^\circ\text{C} = 288.2 \text{ K}$$

i) Using Mg

$$\begin{aligned} V_{\text{H}_2}(\text{Mg}) &= \frac{m_{\text{Mg}}}{M_{\text{Mg}}} \times \frac{\# \text{ mol H}_2}{\# \text{ mol Mg}} \times \frac{RT}{P} \\ &= 5.25 \text{ g} \times \frac{1 \text{ mol Mg}}{24.31 \text{ g}} \times \frac{3 \text{ mol H}_2}{3 \text{ mol Mg}} \times \frac{8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 288.2 \text{ K}}{91.7 \text{ kPa}} \\ &= 5.64 \text{ L} \end{aligned}$$

ii) Using H₃PO₄

$$\begin{aligned} V_{\text{H}_2}(\text{H}_3\text{PO}_4) &= CV \times \frac{\# \text{ mol H}_2}{\# \text{ mol H}_3\text{PO}_4} \times \frac{RT}{P} \\ &= \frac{1.50 \text{ mol H}_3\text{PO}_4}{\text{L}} \times 0.100 \text{ L} \times \frac{3 \text{ mol H}_2}{2 \text{ mol H}_3\text{PO}_4} \times \frac{8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 288.2 \text{ K}}{91.7 \text{ kPa}} \\ &= 5.88 \text{ L} \end{aligned}$$

∴ Mg is the L.R. and 5.64 L of hydrogen is produced.